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CHILD DEVELOPMENT



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SOCIALIZATION AND THE PARENT - CHILD RELATIONSHIP¹

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To those who deal with parents, it often seems that by the time a theory has been put into actual practice by parents, it is no longer accepted. We often wish that some of the publicized methods had been tested in real life situations before being advocated so strongly. While it is true that practice may lag a generation or two behind theories of child development, there is a section of the culture, an *avant garde*, which is much quicker to learn about and adopt the newer scientific opinions. There are intellectual parents who experiment with such methods as self-demand schedule, raising babies in boxes, release of repressions in play or the use of group decisions in determining family policy within a few years of the time the ideas were first discussed in scientific literature. This intellectual section of our culture thus provides an experimental proving ground which we should exploit as fully as possible to observe impartially the actual consequences of modern scientific theories of child development. It is the purpose of this report to explore some of the consequences of "democracy in the home" upon the personality development of young children.

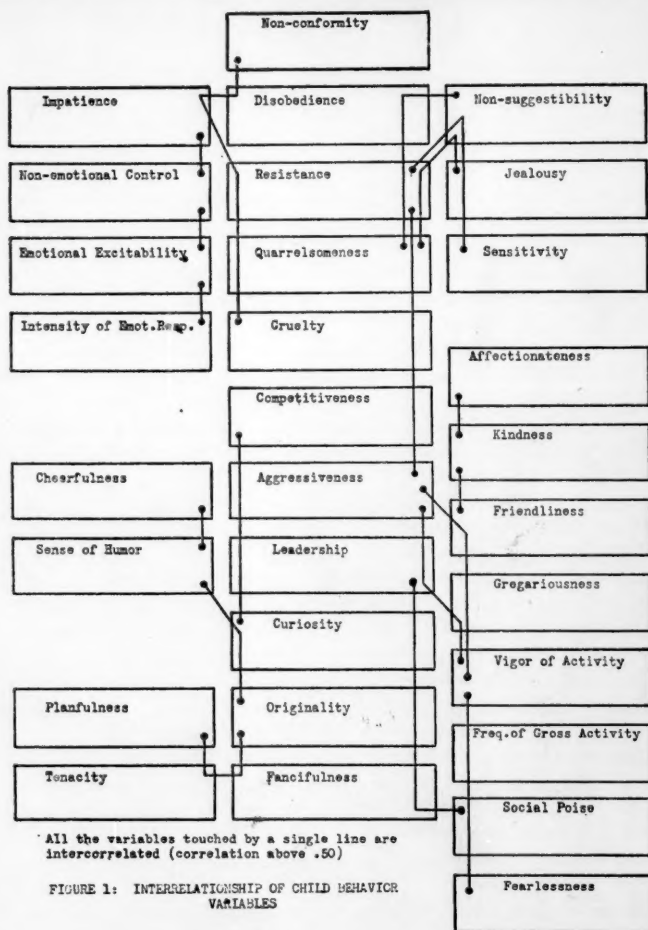
It is well to recognize the limitations of this proving ground as an experimental test of the applicability of various theories. The intellectual culture is certainly no random sample of the culture as a whole. Therefore, the methods of raising children practiced by these people are inevitably colored by the fact that they have a high verbal intelligence; they put a high value on rationality and intellectuality; and they substitute "progressive principles" for the traditional middle-class values without markedly reducing the compulsiveness of their adherence to these principles.

The research which I shall discuss here is based upon the observations of preschool children in the experimental nursery school conducted by the Fels Research Institute. Each child of preschool age attends this nursery school for a month each year during which time he is rated upon a battery of child behavior variables. Concurrently, he is visited in his home every 6 months by an independent investigator who rates the impact of the home environment upon the child in terms of a battery of Parent Behavior Ratings. The sample used in the present study is a group of 67 children, who were observed at the approximate age of 4 years both in the free play group and in the home.

¹Paper presented at a general meeting of the Society for Research in Child Development held in Chicago, Ill., December 27, 1947.

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Figure 1 is a diagram showing the interrelationships among the various child behavior variables. The variables have been so placed upon the sheet that those which are highly correlated are close to each other spatially.



A group of variables whose members are highly intercorrelated with each other form, for the purposes of this report, a syndrome. The members of the various syndromes are indicated in the diagram by a line which extends from the variables at one border of the cluster through all the vari-

ables in the cluster to the variable at the other side. The end points of a cluster are indicated by a heavy dot at the end of the line. It will be seen that many syndromes overlap. In some cases these overlapping clusters will on further examination be combined into a single larger one. In other cases the overlapping variables have very different significance in the two syndromes. For example, aggressiveness and competitiveness take on a particular flavor in the cluster composed of *aggressiveness, competitiveness, leadership* and *curiosity*. In the cluster composed of *aggressiveness, competitiveness, cruelty, quarrelsomeness* and *resistance*, the same two variables have quite a different meaning.

There is evidence for a general factor in this battery of variables, a factor which might be called activeness, or maturity, or good nursery school behavior. The bottom of the diagram tends to represent the socially positive aspects of activity; the top represents the more rebellious and uncontrolled aspects of activity. The right side of the diagram includes variables which describe *inter-personal* relationships; the variables at the left are more impersonal. With this orientation to the battery of child behavior variables, we can proceed to analysis of the consequences of freedom and permissiveness on the one hand, and restrictiveness and pressure on the other.

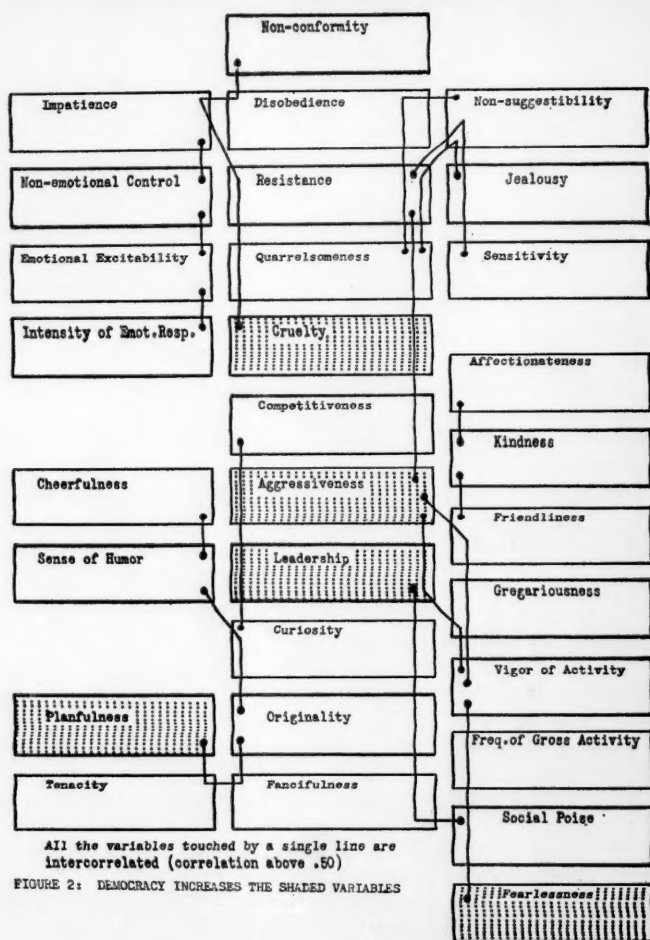
When the variables in the Parent Behavior Rating Scales, used in the appraisal of the home environment, are factor analyzed, two of the factors which are closely related to this problem are democracy and control. Democracy is characterized by a high level of verbal contact between parent and child, appearing as consultation about policy decisions, as explanation of reasons for the family rules, and as verbal explanation in response to the child's curiosity. Accompanying this flow of verbal communication is a lack of arbitrariness about decisions and a general permissiveness plus restraint on emotionality. The second factor, control, is correlated with the first. It emphasizes the existence of restrictions upon behavior which are clearly conveyed to the child, although not necessarily arrived at democratically. Another characteristic of control is the lack of friction over disciplinary decisions. This lack of disagreement might stem from various characteristics, prohibitions on talking back, easy conformity by child, or the determination of the policy by mutual agreement. These two factors are correlated; most democratic homes are not uncontrolled.

If the consequences of these two factors on the child's behavior in nursery school are analyzed together, i.e. if the effects of democracy are studied, keeping control constant, and the effects of control are studied, with democracy kept constant, the following results are obtained:

Democracy tends to have two sorts of effects upon the child's behavior as illustrated in Figure 2. It tends to accentuate by a statistically significant amount the variables which are shaded in the diagram. It seems generally to raise the activity level and to produce an aggressive, fearless, playful child, likely to be a leader in the nursery school situation, but who is also more cruel than the average child of his age. These are the statistically

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significant effects; other variables on which the differences are almost significant are *curiosity*, *non-conformity* and *disobedience*.



Control has not only more significant effects as shown in Figure 3 but they are in the opposite direction. It tends to decrease *quarrelsomeness*, *negativism* and *disobedience* but at the same time to decrease *aggressiveness*, *planfulness*, *tenacity*, and *fearlessness*.

Occurring together, control and lack of democracy produce very marked

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effects in a large number of variables, as shown in Figure 4. The combination produces a quiet, well-behaved, non-resistant child who is at the

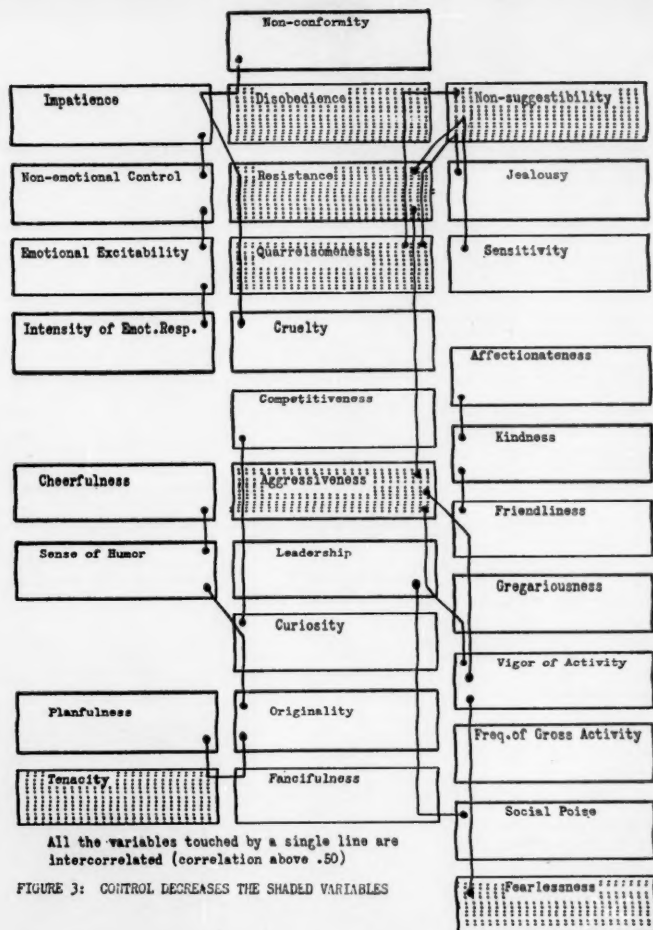


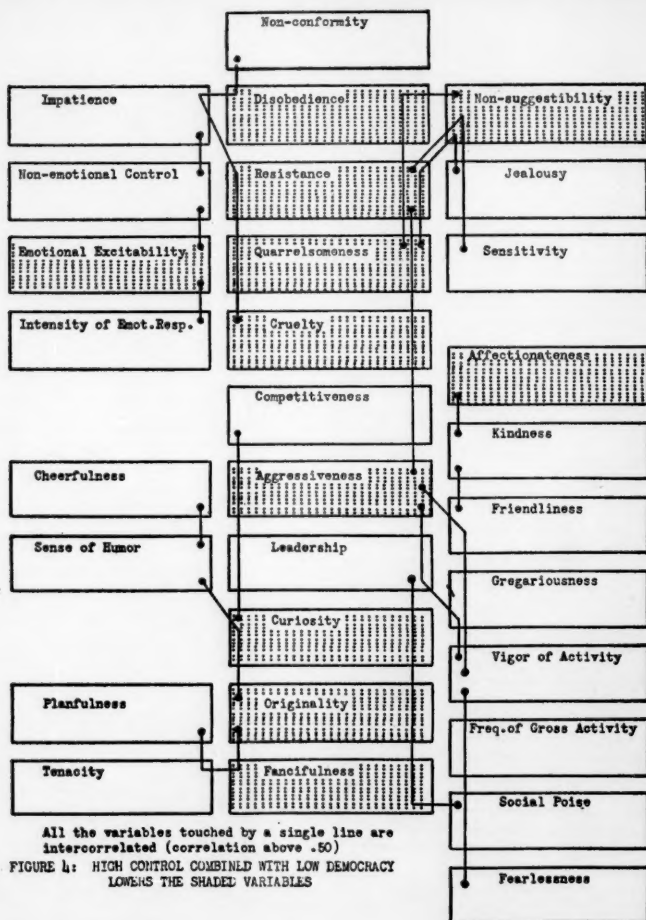
FIGURE 3: CONTROL DECREASES THE SHADED VARIABLES

same time socially unaggressive and restricted in his curiosity, originality and fancifulness. The opposite picture of high democracy and low control produces opposite effects, but very few of the variables are significant.

Thus far, the results generally confirm most of our impressions of the effect of freedom and restrictiveness upon socialization. Socialization by

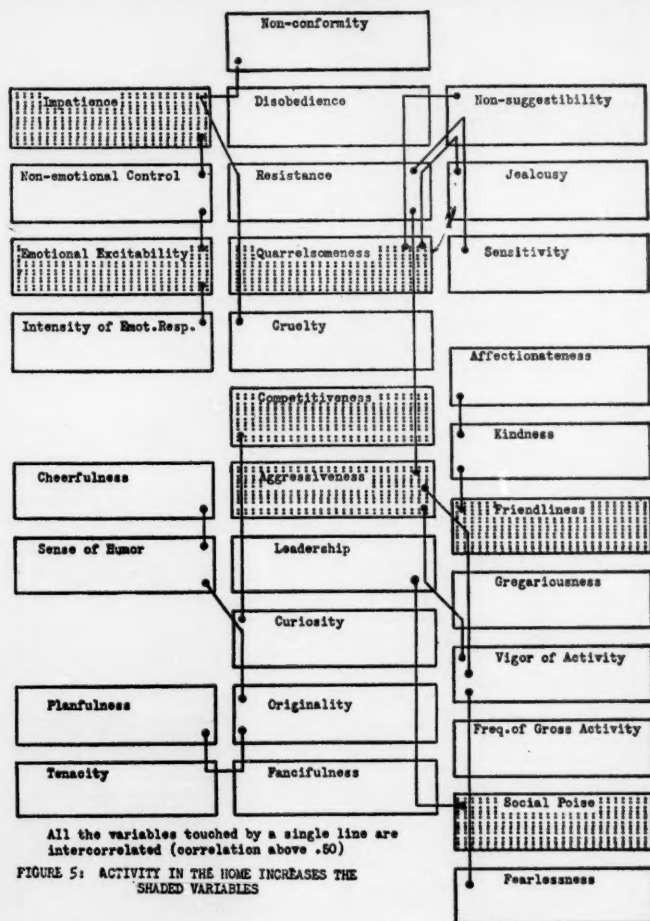
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definition demands the development of contradictory aspects of the personality. Conformity to cultural demands is not easily obtained without



robbing the child of that personal integrity which gives him a mind of his own and which supports him in his attempts to satisfy his curiosity and to carry out his ideas and phantasies in his dealing with the real world. Authoritarian control seems to do just that; it obtains conformity but at the expense of personal freedom in areas which are not intended

to be restricted. Democracy runs the risk of producing too little conformity to cultural demands; but as actually practiced in the Fels families, it

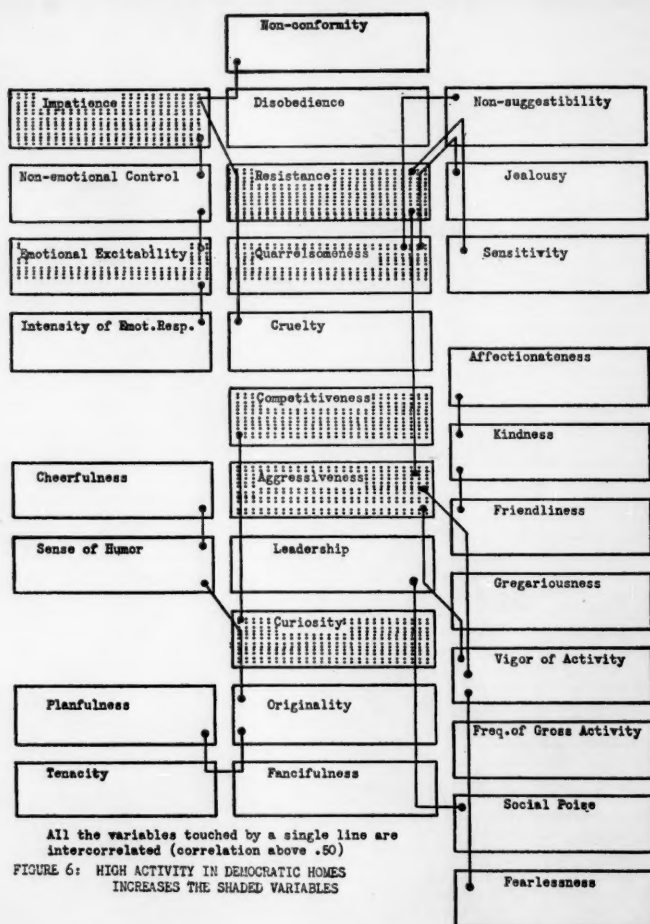


seems to be accompanied by sufficient control to avoid the more serious consequences of this risk.

A third aspect of the home environment, its general activity level, is closely related to these problems of socialization. The active home is characterized by a high level of interaction between the parent and the

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child. In different homes this interaction takes different forms: In some it appears as a well ordered schedule; in others as a continuous flow of



criticism and suggestion; in others as child-centeredness of the home activities; in still others as special training and acceleratory attempts. But if active homes of all varieties are compared with inactive homes as shown in Figure 5, it appears that activity in the home generally raises the child's level of activity in nursery school, and again it raises both the rebellious

non-conforming aspects as well as the socially positive aspects. Activity and democracy have similar effects, but it is possible to differentiate between them. Activity in the home seems to affect the variables describing personal relations rather than curiosity and planfulness which are increased in the democratic home. Activity also differs from democracy in affecting the emotionality variables.

The exact relationship between activity and democracy is revealed by a study of their interaction. There are in this sample about the same number of democratic inactive homes and democratic active ones. These two groups show some rather marked differences. That is, activity is an important factor affecting the child's behavior in democratic homes while in non-democratic homes, activity plays a less important role. Figure 6 shows the effect of activity in democratic homes. The shaded variables are those which are significantly greater in democratic active homes than in democratic inactive homes: *aggressiveness*, *competitiveness*, *quarrelsomeness* and *resistance*, plus *curiosity* on the one side, and on the other *emotional excitability*, *intensity of emotional response* and *impatience*. *Cruelty* too is almost significantly greater.

These findings indicate the advisability of attempting to discriminate among the various kinds of democratic homes. In the inactive democratic homes there is, by comparison with the active homes, more detachment of parent and child; democracy is more casual and less ideological; the level of verbal interchange which characterizes democratic homes is more lethargic and spasmodic; there is more *laissez-faire* and less leadership. In this type of home the effects of democracy are less marked than in a home where there is a high level of interaction. That such a condition would result in a less active approach to the world is reasonable. Hereditary factors probably play a role, but in addition, an unresponsive environment can certainly stultify active expressiveness and aggressiveness toward the world. The child requires not only freedom but response and encouragement if his wishes and his emotions are to be expressed actively, particularly in his relations to people.

These findings suggest that the predominant effect of parent behavior upon the socialization of the preschool child is to raise or lower his willingness and ability to behave actively toward his environment. Freedom and permissiveness in the home by not punishing his active explorations and his aggressive reactions to frustrations, permits the child to become active, outgoing and spontaneous. Freedom alone does not, however, actively encourage the development of spontaneity; a high level of interaction between the parent and child is required to push the child into activity, particularly of the interpersonal variety. The child's expressiveness must be elicited by the parent's spontaneous expression of warmth and emotionality, and the child's attempts to establish emotional contacts with other people must be greeted with warmth and reciprocation, if he is to develop the pattern of habitual expressiveness.

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This activity level of the child seems a prerequisite for socialization, but it is obviously not the whole picture. A high level of activity is accompanied, during the preschool years, by non-conformity and rebelliousness. At this early age, the child responds to stimulation in a generalized and undifferentiated manner, not as yet discriminating between the social and the anti-social forms of activity. The active child, by predisposition or environmental encouragement, is able to express his hostility, but by the age of four he has not, generally speaking, learned how to manage it. The inactive child, does not have the same problem of management of hostility; for him the problem is an intrapersonal one which cannot be adequately investigated by this sort of a statistical analysis of overt behavior. The inactive child's problem, on the overt level, is that of achieving a satisfactory degree of social interaction. The important question from a practical point of view might be stated as follows, "Which of these various patterns of preschool behavior is most likely to lead to a healthy adjustment?" We in child development seem at present to believe that spontaneity, even if it involves rebelliousness, is a sign of good preschool adjustment. Whether that belief is true, true in some cases, or untrue, must be discovered by further research.

PSYCHOSOMATIC PROBLEMS IN CHILDHOOD¹

GEORGE J. MOHR, M.D.

Since this paper is presented as part of a discussion of "Biological Factors in Personality Formation," I shall center my comments about the intimate relationships between common somatic symptoms and disturbances encountered in infancy and childhood and disturbance or deviation of the developing personality of the child. These relationships are more readily observed in small children than in adults because of the more obvious vulnerability of the child in his exposure to a healthy or to a disturbing physical and social environment.

In childhood, the nature of the disturbances that may be designated as "psychosomatic" are dependent upon the biological maturity of the organism (1), and the nature of the nursing and training care to which the child is exposed (2). In the very young infant, the state of physiological maturity and susceptibility to the particular kind of care offered are reflected most commonly in the gastro-intestinal behavior. Appetite disturbances ranging from those that are mild to anorexia that threatens life, reflect errors on the part of the mother in meeting the child's initial need. For the growing infant and child, maternal love and care are essential for the development of security in all life relationships. The feeding situation is, for the child, an experience that initially secures for him comfort and a sense of well-being. When a good nursing or feeding regime and satisfying initial relationship between mother and child are not established, deep discomfort for both follows.

There centers about the gastro-intestinal system and its functioning an essential expression of child's need, mother's readiness or capacity to meet that need, and all the possibilities of fundamental gratification or deepest deprivation for the child. Throughout life, the gastro-intestinal system continues to "mirror the emotions better than any other body system." Menninger (2) remarks that this in part may be because it is partially under voluntary control, and adds, "Next to the skin, the gastro-intestinal system has more contact with the external world than any other part of the personality. It receives more direct demands for adjustment and accommodation, more insults and abuses, and a greater variety of opportunities for gratification than any other set of organs suffers or enjoys."

In early life when there is adequate gratification through establishment of a healthy nursing or feeding regime by a stable mother, the clinical picture of a "normal" infant who thrives physically and gives evidence of comfortable adjustment to his protective environment is usually presented. The implications of such a favorable situation for the healthy personality development of the infant need not be stressed here, and is abundantly

¹Paper presented at a general meeting of the Society for Research in Child Development held in Chicago, Ill., December 27, 1947.

discussed in the literature of child development (3). On the other hand, the pediatrician encounters many problems that reflect disturbance in the child's initial relation to his world. Anxious mothers who overwhelm the child through overconcern about the details of feeding, or repudiating mothers who, out of guilt, exert undue pressure upon the child that provokes resistance from him, are soon faced with the problem of the child who does not eat well. Depending upon the intensity of the pressure, or of the repudiation as experienced by the child, grave symptoms reflecting the deep disturbance in the child's emotional orientation may develop.

Anorexia nervosa, also called, is one expression of a child's inability to cope with the tensions created by anxiety and hostility that develop in an emotionally depriving family milieu. A history of a child who has reason to feel himself to be unloved and who develops deepest feelings of resentment and hostility towards the presumably depriving or threatening persons in the family setting is consistently found. Children thus deprived are anxious children, and their own hostile feelings increase this anxiety. Published case histories (4) expose in detail the psychological dynamics underlying this unhappy conflictful life situation. The later role of anorexia in the unsuccessful struggle of adolescents with problems involving separation from parents, fear of their own aggressive and sexual impulses and strivings, may have its beginning in the early disturbance here referred to (5). I should like to mention that not only refusal to eat, but addiction to eating can also be an expression of an unsuccessful struggle to cope with ungratified, dependent wish or need, the hostility engendered by the deprivation felt, and, on the other hand, the anxiety provoked by exposure to the opportunities, temptations and responsibilities of adult life.

It may be that the feeding situation is successfully met by both mother and child, but that initial tensions develop as a result of undue pressure in relation to bowel training. If training in cleanliness is attuned to the child's readiness to conform to training stimulus and restriction, by correct timing and lack of undue pressure, the child may readily develop the pattern of behavior desired by the parent. But if pressures are premature, or too great, disturbing results can be achieved. A child may be able to meet pressure through overt defiance and open resistiveness, and becomes the stubborn or destructive child. But many a child may be coerced into an apparent conformity, who nevertheless betrays his discomfort or resistiveness. Constipation in such children is an evidence of such resistiveness; they can hold out against the demands of a parent after all, or perhaps, at times, provoke the interest or concern of the parent. When Hirschsprung's disease is diagnosed, the problem of management may be primarily one dealing with the attitudes of anxiety, resentment and hostility that have been engendered by the concern and pressure relating to bowel functioning. This constitutes a problem in psychotherapeutics; when hostility can more directly be expressed without undue anxiety, the somatic symptom may no

longer be overemphasized and a more realistic attitude toward his problem possible for the child.

Ulcerative colitis in children, as well as in adults, has been demonstrated to be a condition highly dependent upon the emotional relationships between the sufferer and members of his family. There is some evidence too, that this severe form of colitis is a reaction to fairly specific type of conflict situation by individuals with given character traits (6). In two cases studied by Sperling (7), onset of the symptoms followed an experience involving separation from the parent to whom the child was dependently attached, in one instance by the child being entered into kindergarten where he was terrified and from which he had to be withdrawn, in the other following departure of the father for military service. In this latter case, at one point during the course of the illness the father had to be given emergency leave to visit the child because of her critical condition. Characteristic in the family situation is a highly ambivalent or repudiating attitude of the mother toward the child. The child evidences deep hostile attitudes toward the mother with fantasies of her destruction or the destruction of others (e.g. siblings) who threaten his security. Such destructive feelings are necessarily repressed, but come to expression in what proves to be the self-destructive bloody diarrhoea of ulcerative colitis.

Enuresis is another symptom long recognized as an expression of psychological tensions. Like the gastro-intestinal system, the urogenital system can serve for somatic expression of tension related to situations of conflict with which the child cannot effectively cope on a behavioral or social level. For some boys, enuresis seems to center about the problem of clinging to a passive, dependent orientation; they are intimidated boys fearful of their relation to more aggressive strivings (8). Some girls evidence "masculine protest" reaction through this same symptom. In each case the somatic symptom is concomitant with a disturbance in personality growth and in psychosexual development. The symptom can be understood, and coped with, through exposure of the underlying psychological disturbance.

In allergic reactions and related disturbances such as asthma, one is undoubtedly dealing with a biologically determined sensitivity, certainly more predominant in some individuals. The pediatrician is familiar with the child who, in earliest life, shows extreme sensitivity at times even to mother's milk, with skin reactions and eczema. Among these are the children who suffer with asthma. Case studies among adults and children (9) have demonstrated that the fate of the allergic individual is not exclusively dependent upon his capacity to respond in an oversensitive manner to foods or other substances that serve as irritants to mucous membrane or skin. Rather specific emotional states play a role in determining whether a child's asthma attacks will be frequent or infrequent, severe or less severe, or occur at all. As with many other symptoms, an asthma attack can be an expression of a child's basic fear of separation from the parent through

fear or loss of parental love. Hostile feelings or sexual strivings play a role in threatening the child's security in a dependent relationship with the mother. With or without a residue or allergic sensitivity, the diminution of physical symptoms may be dependent upon alleviation of the emotional stress.

Tensions that cannot be mastered by the child and expressed in integrated action or adjustment, may be expressed through the muscular system as well as through the activity of the several organ systems. Speech disturbances, tics, and perhaps some convulsive disorders of childhood would be representative of such psychosomatic conditions.

Study of children in psychotherapy, who manifest tics, has demonstrated rather characteristic disturbances in their familial relationships and, again, with fairly consistent reaction of the children to this disturbance. Children who suffer with tic are likely to be externally reserved in manner and polite. An underlying deep resentment or hostility toward adults considered to be restrictive or intimidating is found (10). Gerard (11) regards the tic as representing an incomplete act of aggression. Levy (12) in this connection comments on the development of tic-like movements in animals restricted in movement. Certainly these children are under restriction in the face of deep feelings of resentment, and the discharge of the accompanying tension through motor movement results. The strong defenses some of these children develop against their aggressive feelings is reflected in the relatively rigid personalities they present to the outer world.

While I have thus far discussed psychosomatic problems of childhood as somatic expressions of tensions the child has not been able to cope with through behavior or through other process of integration, it is of equal importance, at least for the clinician, to study the influence of somatic disturbance on personality development. From this point of view, all illnesses of childhood are "psychosomatic" problems, inasmuch as any disturbance is likely to affect the developing personality of the child. It is obvious that if a growing boy suffering with rheumatic fever develops a cardiac involvement that imposes a long period of convalescence, even if the cardiac condition clears up entirely, there are likely to be psychological repercussions. If the illness actually imposes a continuing restriction of activity, which may also be overemphasized by anxious parents, reactions on the nature of self-depreciation, anxiety in competitive relations with other boys, withdrawal from more active situations calling for a boy's more aggressive potentialities tend to occur.

Children who suffer with diabetes are particularly exposed to a situation that has disturbing potentialities relating to character and personality development. A young diabetic patient, a boy of eight, was seen because of obsessional ideas and phobic reactions. For some time he reacted with greatest anxiety to the mother's steps in weighing and measuring foods, his idea being that if she made a mistake about this, it would be the equivalent of poisoning him through having too much or improper food. At

all times he remained most conforming and meticulous in carrying out dietary regulations, which were not stringent. He learned to give himself the necessary injections of insulin. He soon gave up the "poisoning" idea, but developed other disturbing ideas. An old lady known to the neighborhood died. He had the idea that perhaps she died because he had accidentally bumped against her in passing some time previously. A playmate was hurt in play; he thought perhaps it was his fault, perhaps he had bumped into him.

In manner and speech, this boy was excessively well controlled and quiet, rarely smiled. He was an exceptionally responsible little fellow, well liked by his friends with whom he played freely. His diabetes was not severe, and his general state of health good. It was evident, however, that the diabetic condition, and the management instituted, was reacted to in an overly meticulous, compulsive manner. The resentment and hostility he felt at the restriction imposed upon him could be expressed only in a manner directed against himself; that is, in fantasies of hostility directed toward others but with much feeling of guilt. The effect is like that of an over-trained child with the inhibitions and restrictions exhibited by such a child.

Not all diabetic children react in this manner. Daniels (13) cites the situation of an adolescent boy, who reacted with embarrassment at leaving group games, at not being able to have a snack with the boys now and then. The apprehensive family tended to put considerable pressure upon him, and even utilized the diabetes as an excuse to impose restrictions that had nothing to do with diabetes. Unlike the little phobic boy, this boy revolted against all the restrictions attempted by the parents. As Bruch (14) points out, authoritative doctors or parents may succeed in having the children accept restrictions with considerable docility, which may be "good for the disease, but not for the child."

In this brief survey of some psychosomatic problems encountered in childhood, it is apparent that a wide range of physical disturbances may be understood as reactions reflecting disturbances in the relationship between the child and the important persons of his familial environment. We consistently find ourselves dealing with the emotional problems of the dependent need and attachment of the child toward parent, the effect of protective or of hostile attitudes of parent toward the child, the child's reaction to his own hostile or destruction impulses and to threat of separation from the parent or parental love. As indicated at the outset, the nature and intensity of these childhood reactions are dependent upon the biological maturity of the organism at the time undue stresses are imposed upon the child, and the nature and intensity of these stresses. A more comprehensive approach than that which I have attempted would include consideration of the role of constitutional determinants in the selection of the given organ system utilized as the vehicle for expression of the tensions with which the child struggles. However, I consider this out-

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side the scope of the present paper. I would lay greatest stress upon an understanding of the intimate and precise nature of the child's interpretation of the familial environment, and of the precise meaning of the parental role in determination of the pathological picture presented. It is obvious that the fundamental therapeutic approach to the problems of childhood here presented would be the preventive approach. A rational mental hygiene of childhood, with appropriate nursing, training and educational program really attuned to the child's progressively evolving needs, would be expected to insure healthy emotional growth and personality development, free of the pathological complications here discussed.

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THE SOCIALIZATION OF THE DELINQUENT¹

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The term "juvenile delinquent" has long vexed research workers. It designates a person whose behavior has violated certain codes, but it does not include *all* such persons. The term "unofficial delinquent" has helped define delinquency as behavior rather than designating "caught" persons. Neither is it safe to assume that the caught persons represent the more serious extreme of a behavior continuum; the application of codes to juveniles in the legal process is known to vary among different courts. Consequently, an analysis of the socialization of the delinquent must recognize at the outset that the definition of delinquent generally used is at best a crude, albeit a practical one.

Socialization is the learning process whereby the child comes to fit himself acceptably into the manners and institutions of the family, the neighborhood, community, and society in which he finds himself. Socialization is the learning of patterns of behavior which are conventional in the society. Socialization includes the curbing and redirection of immediate and direct gratification of basic needs; it also involves the acquisition of the so-called "derived needs"—status feeling, gregariousness, etc., as well as many specific attitudes and feelings.

SOCIALIZATION OF THE CHILD

Child psychologists have described rather well the broader aspects of the socialization of the young child, although they have not always recognized the ethnocentric nature of their description. Ethnologists have supplied a corrective in their descriptions of child socialization in other societies. More recently, Warner, Davis, Havighurst and others have shown that the process varies appreciably in many specific ways in different subdivisions of our own society. Presumably, these differences have something to do with the adult personality that eventuates from the socialization process. Until more complete studies are available however, we must be content with the generalization that personality variation within sub-groups of American society is probably as great or greater than the variation between such sub-groups.

When one addresses himself to the topic of the socialization of the delinquent, he is concerned principally with the later childhood and adolescent years. Delinquency is strikingly a phenomenon of adolescence. Young children frequently are designated as "problem children" or "be-

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havior problems." Some of the problems noted in younger children disappear as the child grows older and interacts with his environment in new ways and at new levels. A number of other such problems may be corrected by therapists or clinicians. Some persist, becoming more organized and overt, and eventuate as delinquencies.

Not only is adolescence the period when "behavior problems" mature into full-fledged delinquencies; it is also the period when the individual makes his transition to adult male or female status. True, as a child, he is a member of a family, a social class, a community. He is subjected to differential treatment because of color, class, or sex, and has developed a number of attitudes toward himself and toward others. But puberty brings new attitudes of the individual toward his physical self, and projects him onto the larger society in a masculine or feminine role quite different from the sex status he carried as a child. These transitions require certain readjustments in parental authority; generally these readjustments are affected readily enough but not always so. Although developing physically as an adult, the individual is frequently subjected to a number of parental restrictions on conduct, to which he does not always accede easily. Then, the adult members of society remark on the various forms of adolescent protest, revolt, and "growing pains."

It should also be noted that the adolescent strives for adult status in a society not so ready as many primitive groups to accord him that status. Moreover, he has this experience in a society which itself is rapidly changing. The adult in the family, confused by the inappropriateness of many of his own habits and beliefs in a changing world, may not be tolerant of changing attitudes and standards in his own young. Or the parent, his own family habits disrupted by the changes in the social order, may neglect or ignore the adolescent—a situation equally confusing to the adolescent, who often seeks moorings in the midst of his "revolt."

The child or adolescent is not merely "socialized." He is an active participant in the process. He has growing concepts of himself and his goals, which help shape the personality he is becoming. He resists certain influences, yields willingly enough to others, accordingly as those influences may run counter to, or are congruent with the flow of his own developmental direction. The person is never merely putty in the fingers of circumstance; he is substance with some resilience and a character of its own. The increased emphasis on this characteristic of the person is seen in the current attention which pediatricians give to "self-selection" and "wisdom of the body," which clinicians give to the integrity of the individual and the striving nature of behavior, and which counsellors give to the "client-centered" approach.

THE COMMUNITY

Socialization is a total process and for convenience one may discuss the delinquent as he relates to each of several of the major institutions of im-

portance in the adolescent's life and experience. One of the most completely investigated aspects of delinquency in the community environment is the so-called "blighted" or delinquency area in the large city. As a social phenomenon this has been very completely described by many sociologists, and as it relates particularly to the delinquent, Clifford Shaw's analyses are classics of their kind (25, 26).

It must be noted, however, that Shaw's definition of the delinquent is the social-legal one. His maps plot the cases brought into court. In a certain large Middle-Western city not long ago, the depredations of Hallowe'en led one sociologist to plot two items which may be considered indices of delinquent behavior—the amount of breakage of street lights, by census tracts, and the replacement of window glass, by schools, for a year. He found a high correlation between the two, but the heaviest areas of replacement coincided with some of the better residential areas. In fact, the zones on a plot-map were almost a direct reversal of Shaw's classic pattern—the breakage was higher consecutively in concentric zones from the city center outwards.

In relation to the court appearance of a number of youth of the city's "better families" in connection with these Hallowe'en depredations, one judge is reported to have remarked that he was seldom privileged to witness such an array of high-priced legal talent. Authorities were openly critical of the parents' attitudes in denying misdemeanors on the part of their children. (Those whose adolescent sons and daughters were actually apprehended in acts of vandalism had a little harder time explaining away, of course.) Such observations show that delinquents may be more difficult to locate in some areas of a city than in others, even though the delinquent behavior exists.

At one time the delinquency area was commonly the home of immigrants, and the culture conflict theory of delinquency was plausible. The blighted area is still the home of transients and lower class persons, and it is undoubtedly true that in the lower social classes personal violence and property offenses are taken much more casually than in middle or upper class levels. However, it cannot be successfully argued that delinquent behavior invariably consists of acts acceptable at one social level (where they originate), but unacceptable at others, particularly the upper-middle class groups who represent the conscience of society.

It can be argued that there are actions which are pretty generally disapproved throughout most levels. Even if each social class had a code peculiar to itself, there would be disapprovals of those individuals within the group who did not live according to the code, hence there would be delinquents recognized by the group.

On the other hand, the psychiatric or psychological definition of delinquency, as behavior of a child seeking to adapt himself and his needs to demands placed upon him, tends to stress personality peculiarities or short-comings of the individual who is not adapting.

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This seeming variance between two theories of delinquency may be over-drawn; probably both are correct. Kvaraceus brings the two theories together when he says "it is highly probable that delinquent aggression has its roots in the conflicts and frustrations that take place in the lower-lower, upper-lower, lower-middle and to some extent the upper-middle classes" (16). There are undoubtedly children whose behavior does not appear very serious to themselves or to their families, because they have never known otherwise. There are also children whose delinquencies portray patterns of aggression developing out of personality problems and frustrations. They are aware of wrong-doing and social disapproval, but seem to be helpless in the grip of emotional forces compelling them into misbehavior.

LEISURE TIME

The community affects socialization in another way. The facilities of a community and its neighborhood traditions influence a child's play, and play life is important in the socialization process. In the first place, play permits the child to use and perfect new activities made possible by the coordinated growth of maturation and learning. The sequences of motor activities in the development of the young child come to mind immediately, and the satisfaction young children seem to get out of the repeated performance of a new activity has been frequently remarked.

Play activities also permit certain substitute satisfactions. Thus, certain aggressive themes in children's playing "house" or "school" may reflect their reactions to the adult aggressions they have experienced in such situations. It is this function of child play which has been utilized so successfully in doll play studies with children.

Play also permits a child symbolically to enter into certain roles which he is learning to accept or which, in time, he will find necessary to develop. Thus, the so-called imitation of adult activities frequently carried out by children, or the emphasis on certain kinds of bold, daring masculine activities by boys, and the developing of home making themes by girls permit a kind of role-taking which reinforce attitudes, even if they do not in our society serve to initiate the individual into such adult activities.

Studies of play interests of delinquent children have almost all been surface or descriptive in nature. We have studied the participation of delinquent children in all sorts of games and activities, but we have not studied these activities as dynamic—i.e., in terms of the functions of the play for the purposes and needs of the individual. Such studies are needed.

The writer has published material showing appreciable differences in the play activities reported by delinquent boys and non-delinquent boys coming from delinquency areas in cities (9, 10). On the basis of such differences, it has been found possible to differentiate rather clearly between groups of legally adjudicated delinquents and non-delinquents. A scoring key derived initially on Minnesota youth has given similar results with

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other delinquent and non-delinquent groups from Utah, Minnesota, Indiana, and Washington, D.C.

Activities consistently differentiating delinquents and non-delinquents the most reflect, first, greater freedom from parental supervision and restraint on the part of the delinquents, and second, identification of delinquents with an independent, free, "tough" pattern of activity. Such items as being out late at night, going to fairs and carnivals, having dates, playing along railroad tracks, frequently going to the movies, especially gangster and Western films, going to poolrooms, going around with older or "hard-boiled" fellows that have money, hitch-hiking, playing poker, pool, "Rummy" for money, bumming around, and similar activities suggest both greater freedom of movements and a particular kind of identification among the delinquents.

Non-differentiating items include constructive, educational interests such as membership in school clubs, experimenting with electrical apparatus or chemicals, making collections, doing hobby or craft work. Sports, such as volley-ball, wrestling, track, football, baseball, and gym activities, are as popular with delinquents as non-delinquents.

The Chicago Recreation Survey (24) kept records of the attendance of all children in playgrounds, play centers, and neighborhood houses in certain districts for one year. The attendance records of known delinquents, unofficial delinquents, and non-delinquents were then compared. In general, it was found that delinquents were, if anything, a little more likely than non-delinquents to avail themselves of constructive play opportunities, and in those situations participated in much the same type of activity as non-delinquents. Such a finding is an interesting behavioral confirmation of the questionnaire findings of the present writer. The Chicago study, however, discovered a slight tendency for the delinquent to seek out more quiet pursuits such as reading or table games rather than organized group activities. The group reinforcements of these children were probably being found elsewhere than in organized centers.

The play activities of delinquents, then, permit the individual to gratify certain personal aims for thrills and adventure and to dramatize certain roles. The delinquent's play activities reflect a greater laxness of parental supervision, a greater freedom to roam widely and to identify with more "mature" kinds of activities common in the delinquency area. This argument suggests that delinquents have a wider community experience than do non-delinquents, and is in agreement with Atwood's findings (1) that juvenile delinquents show a greater amount of social contact and participation.

HOME AND FAMILY ADJUSTMENT

The factor of poor family adjustment is one of the most consistent findings of research on the delinquent child. At least two studies have found the home adjustment scale of the Bell Adjustment Inventory to differen-

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tiate significantly between delinquents and non-delinquents, whereas health and social adjustment scales made no such distinction. The emotional adjustment scale separated the delinquents and controls significantly in the Bartlett and Harris study (3), but not in the Merrill study (18). Krause (15), however, found no difference in the home adjustment scale of a modified form of the Bell; he did find a poorer school and emotional adjustment, however. The well-known Healy and Bronner study (13) of delinquents and their non-delinquent sibs also revealed the poorer family adjustments of the delinquent children. Data in the Merrill study (18) suggests that delinquents are considerably less ego-involved in the home situation.

Bach and Bremer (2) in a comparative study with smaller numbers of cases have suggested that delinquent boys showed more indifference to their fathers than normally adjusted children, who gave significantly greater evidence of aggression received from fathers and of hostility felt toward father's aggression, as well as evidence of more affection received from father. They suggest further that the delinquent has a weaker disapproval anxiety as contrasted with the normally adjusted. That there is actually less parent-child interaction in the case of delinquents agrees with the anecdote reported earlier, wherein the well-to-do parents of children brought into court were judged to be indifferent toward their children's behavior and quite unconcerned over the desirability or necessity of any supervision of adolescents' hours or activities.

Very little work has been done on attitudes of delinquent boys toward parents, but it appears sound to conclude that delinquents typically are not as closely knit into family experiences. Consequently, their socialization experience in the primary group is different from that of non-delinquents.

SCHOOL ADJUSTMENT

The school adjustment of delinquents has been uniformly reported as poor. One of the early single signs of delinquency is chronic truanting from school. In various groups studied, the delinquent is typically three years retarded educationally, and likely to test even below his placement level in achievement tests (17). Even when differences in mental level are allowed for, the delinquent has frequently failed to achieve. That schools should adapt their curricula to slow learning, or uninterested children is a recurring theme in the various pleas that are made for delinquency prevention (20). The delinquent thus does not do too well in a major experience in the lives of most adolescents—work and social life under auspices of school teachers. In this area, then, the delinquent is not sharing equitably or effectively in the socialization process of youth, and, as has so frequently been shown, this being out of step may date back into the elementary grades and be a persistent and cumulative phenomenon up into the junior high and high school.

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THE PEER GROUP

Perhaps the most significant aspect of the socialization of the adolescent is the peer group. Zachry (31) and Tryon (29) in their studies of adolescents have made this factor central to the adjustment of the adolescent. Kingsley Davis (6) argues that the inconsistent and contradictory attitudes of adults combine to drive the adolescent into the company of his peers. Sherif and Cantril (27) hold that the indifference or neglect of parents of delinquent type children force those children to discover status in gang activities of contemporaries to an even greater extent than the typical adolescent.

It is the opinion of Thrasher (28), whose work on gangs is well known, that the juvenile gang arises out of the spontaneous play group. We have seen that delinquents exhibit a characteristic pattern of play interests as contrasted with non-delinquents. The play group which develops into the gang is important in juvenile delinquency, for delinquencies are rarely "solitary" activities. In one survey 82 per cent of all delinquents studied committed their offenses as members of groups (26, p. 167). Of stealing incidents alone, 89 per cent of all offenders came to court as group or gang members.

It is interesting to note that Hart's (11) factor analysis of 25 traits in 300 delinquent boys yielded six factors, at least four of which have a distinct group reference: temper-assault, general compensatory behavior, aggressiveness, leadership, street-gang activity, and group stealing.

A review of the extensive sociological work on gangs brings one to the view that group activity of the delinquent is a very natural and normal effort of youth to seek approval, status and purpose. In the delinquency area, with its fewer inhibitions and supervision, group behavior is likely to take undesirable forms (28). Thus, as Whyte says, gang activity may be evidence of the individual's seeking and attaining a measure of meaningful social and personal life rather than evidence of disorganization or disintegration (30). Gangs generally are very well organized, both as to purposes and modes of action. They exact a distinct loyalty from the members, who exhibit a marked "we" feeling. Group slogans and norms arise. In the gang the individual finds a meaningful conception of himself. As the members grow out of adolescence, marry, and find new channels for status and recognition, many drop their gang activities. Relatively few persist in organized crime (28). Such observations fit closely into the Gluecks' (8) theory of maturation applied to juvenile crime. They find that the passage of time seems to be the principal factor in causing delinquents to reform.

Some work has been done on the self-attitudes of delinquents. Daniel (5) found Negro delinquents more critical of the "average boy" and more frequently expressing feelings of superiority to the "average boy" than the non-delinquent. Reusser (22) concluded that delinquents feel themselves

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more different from the "average boy" than do unselected boys. He considered the delinquents more out of touch with the attitudes and ideas typically held by unselected boys and somewhat less able than unselected boys to estimate the feelings of others. Rubenstein (23), comparing well-adjusted and maladjusted cases in an institution for dependent children, has stated that the well-adjusted more often report themselves as superior to the "average" child, and that the maladjusted report feeling inferior more frequently and are generally more self-critical concerning various matters of thought and behavior. Well-adjusted children criticize other children for anti-social acts and thoughts, while poorly adjusted children criticize others on relatively innocuous behavior. Such findings indicate the need for study by a variety of techniques, projective as well as questionnaire, to rationalize this matter of self-appraisal and the self-image in relation to socialization.

THE MORAL CODE

Another experience in socialization is the adjustment to the larger social code, or the code of the prevailing social group. Tests of moral knowledge generally show that such knowledge is not too closely correlated with ratings of character or conduct. One study, using a standardized test of the right thing to do in certain situations, found that delinquents are quite as versed in the verbal analysis of moral situations as are non-delinquents (3). This same study showed delinquents to be as informed in Biblical names, places, and concepts as non-delinquents, which finding agrees in general with the low correlations reported by Hartshorne and May (12) between religious practice (such as Sunday School attendance) and ratings of character, a conclusion also supported by Hightower (14). The various studies of gang behavior attest that general social norms may be fully understood without being accepted by the individual. These studies clearly show how juvenile groups develop their own standards which are accepted by the members and do become influential.

The necessity of differentiating between formal and functioning standards verbalized by the person is attested by a considerable body of data. Middleton and Wright (19) show that delinquent girls have more favorable attitudes than non-delinquents on the Thurstone scales toward the law, God and the Church. Bishop (4) states that scales of the Thurstone type developed for a series of "good" and "bad" social habits fail to reveal differences between delinquents and non-delinquents.

On the other hand, Bartlett and Harris (3) found that an attitudes test toward a series of social acts did differentiate significantly between delinquent and non-delinquent boys. The writer is of the opinion that attitude studies of this type, where items are related not only to each other but also to an hypothetical absolute standard of moral judgment, and scales which compare a person's own attitude to what he thinks others believe, may

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yield valuable information on this problem of the interiorization of standards.

Another area which appears to be significant and in which little work has been done is the attitudes of delinquents toward money and work. Durea's studies (7) have suggested that the typical delinquent admires prestige, especially that conferred by good looks, dress, money, physique and display. He admires occupations and people who are in the "conspicuous consumption" class or whose work is thrilling, adventurous, or prestige-gaining, such as professional athletes, movie stars, circus performers. Here again the inference is strong, that delinquents get tied up with a series of standards which are superficial and more likely to appeal to the immature.

Sherif and Cantril (27), in discussing the ego development of the adolescent, make delinquency principally a matter of conflict of parent and adolescent norms. Delinquency is held to be an expression of adolescent maladjustment to primary group standards, or failure to interiorize those standards, with resultant identification with peer groups.

It is necessary, however, to recognize that most, if not all adolescents, experience some measure of conflict with parents or with prevailing social norms, while only a few are classified as delinquent. Why the minority only are censured for their deviations from norms, probably must be explained partially in terms of the relative number of times and the flagrancy with which norms are violated, and partially in terms of the degree of finesse in covering up deviations or placating offended elders. Partially, too, it may be a matter of family prestige.

Porterfield (21) found that a group of college students admitted to a series of juvenile delinquencies quite as serious as those noted in a sample of court offenders. The offenses had apparently not been as frequent in the college group, however. Differences in socio-economic status and family organization were held to explain in part the relative impunity with which students could commit delinquencies and also to explain the differential after-careers of the two groups.

After all, social norms do change and the change may well be brought about by the modifications wrought in norms as they are interiorized by successive generations of adolescents undergoing the socialization process.

SUMMARY

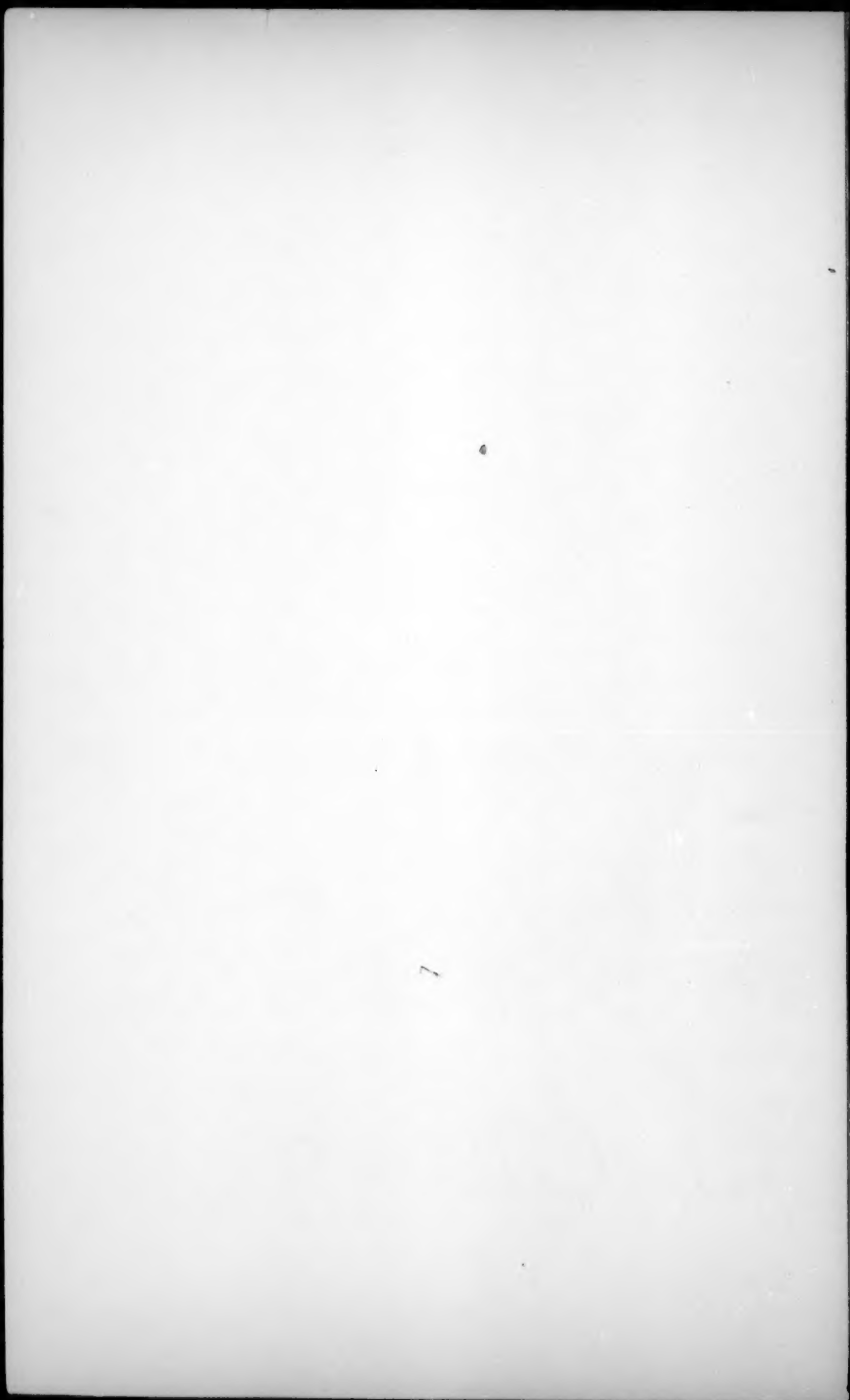
A study of the delinquent, then, introduces no new factors in the socialization process. Contrary to popular thinking, the delinquent is not "socially maladjusted." He is frequently quite well socialized, but in terms of standards and group applications too deviant to be acceptable to the larger social body. He is an adolescent who frequently comes from an environment in physical transition, where family and neighborhood social controls are likely to be casual or nonexistent. Generally, he is not closely knit into a

family structure which supplies ego reinforcement and aids the process of interiorization of adult norms. He seeks status and ego development in peer groups where adult influence and restriction will be at a minimum. Quite uniformly the delinquent has failed to participate effectively in the school environment for some years prior to his delinquency; hence, he is out of touch with experiences shared in by most of his age-mates. Researches on the play interests of delinquents confirm the judgments of many observers, that the values of the delinquent are frequently superficial and "attention-getting." His activities indicate an early identification with ways of behavior usually forbidden children but generally tolerated in the adult—smoking, drinking, being out late, gambling, and the like. There is ample evidence that the delinquent is quite conversant with the wide social code, yet there are suggestions that on an absolute basis as well as on a relative basis his values are scaled somewhat differently than are similar values in the experience of non-delinquents. Much more research is needed, not only on the values that are accepted, but also on the process by which they become "interiorized."

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THE MEASUREMENT OF THE MENTALITY OF INFANTS

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The measurement of the intelligence of infants presents all the problems of measurement in other fields as well as a few special problems of its own. Two of the more serious of the latter type are: 1) can the intelligence of infants be measured? and 2) granted that it can be, how predictive will such measures be of later ability?

To the first question the best answer that can be given is that there is disagreement among authorities in the field. But the fact that several attempts have been and are being made at least indicates a hope that such measures are possible.

To the second question—the later predictableness of test scores—two rather categorical but diametrically opposed answers have been given. Nancy Bayley (1) tested each of 48 children eight times between one month and their ninth birthday. Correlations between early consecutive tests were as high as .57 but between early tests and those at 18 months they approached zero and with later tests they reached a negative correlation as high as —.21.

In interpreting Bayley's results the following facts should be kept in mind.

1—Her tests like most others of that time contained many tests of physical and maturational processes.

2—The reliability of her early tests was low, .51-.74. For later tests it was .85-.95. Validity was not measured.

3—Her test group was very atypical. The mean I.Q. at 9 years was 134.

It is hard to understand why her correlations would become negative between early and later tests. It seems paradoxical at least that a high early score would indicate low later ability and vice versa. Could it be that her tests like the Babinski reflex measure characteristics which tend to disappear in the normal child?

In contrast Gesell believes that early tests give accurate information about later development. His position is well summarized in "Biographies of Child Development." He says "The behavior biographies which we have just reviewed give clear evidence of a high degree of latent predictability in the early sector of life. In the whole series of 30 diversified specimens there is no instance in which the course of trend of mental growth has proven whimsical or erratic." Sixty cases studied later generally support the same view, that is, early test scores predict later levels of attainment.

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For the last six years the author with the assistance of several collaborators has been constructing a new infant intelligence test.¹ The general aim has been to select predictive items which measure adaptation to physical and social environment. First, all previous tests were collected and analyzed. Roughly one-third of the preliminary test was chosen from these sources—and largely from Gesell. Nearly as many more were adapted from such sources but with some change in method of giving or scoring or both. The remainder were new tests devised largely by comparing the behavior of younger and older babies in order to note signs of development.

A preliminary battery of test items was constructed and given to a group of infants at the Evanston Cradle (2). An analysis of the results was made on the basis of the objectivity in giving and scoring of the tests and evidence of age-grade progress on the tests. On the basis of these results a new test was devised. It was divided into three parts. There were 15 items in what was called a 4-week test, 19 items in an 8-week test, and 19 in a 12-week test. Several of the items of the 4-week test were repeated in the later lists. As a result of further giving and analysis, the tests were again revised. Several items were dropped and others were added. This produced a test consisting of 19 items in each of the three sections. In practice all these parts were generally given to each child and tentative norms were developed for each age on each part as well as on the whole test.

This battery of tests was administered to between 400 and 500 infants mostly from the Cradle, but others were included from the Florence Crittenden Home in Peoria, St. Vincent's Orphanage in Chicago, and several babies in private homes, mostly from the faculty and married students at Northwestern. Scores for many tests had to be discarded because the tests were incomplete or improperly given or recorded. A person without experience in giving tests to babies hardly realizes the difficulties involved. Much has been written about rapport in giving tests to adults. No adequate discussion of this problem with infants has been discovered. It is even more important and difficult to attain rapport with infants than with adults. There is no use trying to test a baby who is sleepy or crying. Tests are generally given between 20 minutes to 2 hours after feeding if the child is awake, dry and not crying. If the child begins to cry, the test is discontinued at least until the crying ceases.

Upon the basis of tests for 276 babies whose records were complete and usable a final revision called the Northwestern Infant Intelligence Test has been completed. The present test consists of 40 items chosen on the basis of four criteria: 1) Tests with definite directions for giving and scoring; 2) Tests that require relatively simple equipment; 3) Tests which measure adaptation to the environment rather than physical growth or maturation; 4) Tests that show definite age-grade progress. That is, only those test items

¹Special credit should be given Dr. Anna Shotwell, who helped assemble the first form of the test, and Mrs. Dee Burks, who has helped with later revisions of the test.

were retained that were passed by increasing proportions of babies from week to week.

The resulting test has a reliability for odd vs. even items for each week from 4 to 11 varying between .79 and .94 with an over-all reliability of .84 when corrected by the Spearman-Brown formula.

Norms in terms of the number of items passed have been established largely on babies at the Evanston Cradle. Norms for each age from 4 to 12 weeks can be derived by the use of the following formula: $\text{norm} = 14 + 1\frac{1}{2}(\text{age in weeks})$. For example, the norm for ten weeks is $14 + 1\frac{1}{2}(10) = 29$. The I.Q. can be determined by giving three points credit for each point of deviation from the norm for any age. That is, a 10-weeks-old baby with a score of 31 would have an I.Q. of $100 + (3 \times 2) = 106$. I.Q.s for 237 cases of all ages gave a mean of 100 and a sigma of 16.

The validity of the test, as has already been mentioned, has been checked 1) by age-grade progress not only on the whole test but for each item of the test; 2) the test has also been given to 97 inmates of the Lincoln State School and Colony, Lincoln, Illinois. For a report on 73 of these cases the writer is indebted to William Sloan, psychologist at that institution. The following is a summary of these results.

Twenty-eight cases classified as spastics and convulsive patients: mean age of 27 months had a mean I.Q. of 6.2 as determined by a method similar to that proposed above.

Twelve were mongols with a mean age of 7 months and mean I.Q. of 23.6.

Twenty-three were hydrocephalics and microcephalics, mean age 14 months and mean I.Q. of 8.1.

Ten miscellaneous cases had a mean age of 16 months and mean I.Q. of 24.4.

These are approximately the scores to be expected of these groups of feeble-minded children.

Of these groups, 29 were also tested either with the Kuhlmann-Binet or Cattell test. The mean difference in I.Q. between the Northwestern test and others was 3.8. In general there is close agreement in test results. The Northwestern, of course, has many more items for use at early ages than either the Kuhlmann-Binet or Cattell tests.

Several of the normal infants who were tested by one of the earlier forms of the test have been given the Stanford-Binet Tests later. While the numbers are too small for statistical analysis, the results thus far have shown high predictive value for the early tests.

The reliability of the tests by the odd-even method, as already stated, was .84. In the earlier form of the test it gave similar results (.87) by the retest method with 4 weeks between tests.

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In summary, a test of 40 items has been constructed with relatively high reliability and evidence of high validity. The test is now to be used to study three problems: 1) To determine whether new norms must be established because the test items have sometimes been taken out of their old settings and partly rearranged in the new test; 2) to test more carefully its predictive value for later attainment; 3) to compare the scores for babies from families with different socio-economic and intellectual backgrounds to determine how early such influences affect test scores.

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PREDICTABILITY OF LEG LENGTH

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The prediction of adult leg length is of considerable importance in the case of children who have had paralytic poliomyelitis. For this reason, some of the material relating to growth in leg length from the Harvard Growth Study has been analyzed. The monograph, *Data on the Growth of Public School Children* (1), includes measurements on a group of 200 white girls of northern European extraction. Anthropometric data are available for this group at each year of age from 7 through 16. Age at the first menstruation is known for 64 of the 200 girls. The methods used in taking the measurements are described in the monograph.

Leg length was not measured directly but was considered to be the difference between the standing and sitting height. This method of estimating the length of the long bones may well be biased, since considerable variation may be introduced into the sitting height by the inclusion of fat and muscle. The measurements studied were:

- 1) Leg length in centimeters at each age, 7-16;
- 2) Standing heights in centimeters at ages 7, 12, and 16;
- 3) Ratio of leg length to standing height at ages 7, 12 and 16;
- 4) Age at first menstruation when it was recorded.

Three problems may be considered. The first is the increase in leg length from year to year and the correlation between the measurements at the different ages. The second is the error in the prediction of leg length at age 16 from different combinations of the variables—leg length, standing height and ratio at age 7 and at age 12. The third problem consists in determining whether the age at first menstruation affects the predictions. It should be stated that because the leg length is a derived measurement, little emphasis can be placed on small differences.

GROWTH IN LEG LENGTH

Table 1 gives the means, increments, standard deviations and coefficients of variation of the leg length at ages 7 through 16 and the means, standard deviations and coefficients of variation of height and ratio at ages 7, 12 and 16. The maximum increase in leg length occurs on the average between the ages of 10 and 11. It has been shown by Shuttleworth (2), on the material from which these 200 cases were selected, that the age of maximum growth differs for various linear dimensions. That of leg length, for example, precedes that of sitting height by about one year. That growth in height and growth in leg length do not proceed in like manner is indicated by the ratios. The ratios were tabulated only at ages 7, 12 and 16. Age 12 shows the highest value.

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The coefficients of variation are of some interest. Those for leg length tend to be greater than those for standing height, while those for the ratio are the smallest of the three.

TABLE I
*Means, Increments, Standard Deviations and
Coefficients of Variation of Leg Length, Height and Ratio*

Age*	LEG LENGTH				HEIGHT			RATIO		
	Mean cms.	Increment cms.	S.D. cms.	C.V.	Mean cms.	S.D. cms.	C.V.	Mean	S.D.	C.V.
7	54.93		3.42	6.2%	120.94	5.44	4.5%	.4540	.0113	2.5%
8	58.12	3.19	3.55	6.1						
9	61.50	3.38	3.77	6.1						
10	64.94	3.44	4.06	6.3						
11	68.50	3.66	4.39	6.4						
12	71.96	3.46	4.25	5.9	150.16	7.50	5.0	.4790	.0112	2.3
13	74.31	2.35	3.98	5.4						
14	75.38	1.07	3.70	4.9						
15	75.75	.37	3.77	5.0						
16	75.82	.07	3.89	5.1	161.20	5.67	3.5	.4703	.0121	2.6

*Ages were measured to the last birthday. Age 7 means between 7 and 8 years.

The coefficients of correlation between the leg lengths at the various ages, between the heights and between the ratios for certain of the ages are given in Table 2. As might be expected, the coefficients between the leg lengths decrease as the difference between the ages increases. The correlation for consecutive ages is lowest for the pair of ages 13-14. Study of the table reveals one curious fact. Leg lengths at ages 10 and 11 correlate less strongly with leg lengths at ages 13, 14, 15, 16 than do the leg lengths at younger or older ages. For example, the correlation coefficients of leg length at 16 with that at 9, 10, 11, 12 are .75, .72, .70, .77. The correlation coefficients between the heights and between the ratios were not computed for all pairs of ages, so that it is impossible to determine if the same decrease is present for these two variables. However, Wilson (3), gives similar banks of correlation coefficients for height and for weight. These were

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computed on measurements of 275 girls from the same source. The group of 200 northern European girls studied here are included in Wilson's 275. Study of Wilson's table shows that the correlation coefficients between the

TABLE 2
Correlation Coefficients between Leg Lengths at Different Ages

Age	8	9	10	11	12	13	14	15	16
7	.965	.959	.934	.909	.900	.866	.788	.745	.728
8		.972	.954	.933	.921	.890	.809	.765	.744
9			.975	.956	.939	.895	.812	.762	.746
10				.972	.945	.891	.797	.737	.719
11					.956	.892	.785	.719	.705
12						.945	.854	.783	.767
13							.926	.864	.847
14								.959	.945
15									.975

*Correlation Coefficients
between Heights*

Age	12	16
7	.882	.752
12		.705

*Correlation Coefficients
between Ratios*

Age	12	16
7	.728	.650
12		.793

heights vary in the same way as do those between the leg lengths. The correlation coefficients between the weights do not show the decreases to the same extent. These decreases, when they occur, seem to involve the ages of maximum growth.

Because the correlation coefficients between the weights, between the heights and between the ratios were not computed at all ages on this group of 200 girls, it is impossible to compare the banks of coefficients with any precision. Wilson's table of coefficients for weight and height shows that the weight coefficients are higher than the height coefficients for ages 11 and 12 with ages 14, 15 and 16. For other pairs of ages, the height coefficients tend to be higher. The height coefficients computed on Wilson's group of 275 girls are higher than the leg length coefficients computed on the group of 200 girls except at ages 11 and 12 with ages 7, 8 and 9. The leg length coefficients tend to be larger than the weight coefficients for

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ages 7 through 13 with ages 7 through 10, but smaller for the other pairs of ages. The only correlation coefficients available between the ratios are at ages 7, 12 and 16. These coefficients are given in Table 2. While there are too few of them for comparative purposes, it is worth noting that the correlation coefficient between the ratios at age 12 and age 16 is higher than the coefficient between the heights or the leg lengths at the same pair of ages.

The correlation coefficients between height, leg length and ratio at ages 7, 12 and 16 are given in Table 3. The height and leg length relationship decreases with age while the coefficients involving the ratio are lowest at age 12.

TABLE 3
*Correlation Coefficients between Leg Length, Height
and Ratio at Ages 7, 12 and 16*

	Age 7	Age 12	Age 16
r _{HL}	.934	.916	.879
r _{HR}	.542	.163	.385
r _{LR}	.796	.527	.702

PREDICTION OF LEG LENGTH

Regression equations for the prediction of leg length at age 16 have been computed. The predictions were based on the combinations of the variables available at ages 7 and 12, namely leg length, height and ratio. The regression equations and the residual variances are given in Table 4. The variance (σ^2) of leg length at age 16 is 15.1. This variance is equivalent to a standard deviation of 3.89 cms. (Table 1). The value, 3.89, represents the amount of scatter about the mean leg length, 75.82 cms., at age 16. The square roots of the residual variances given in Table 4 show the amount of scatter to be expected in leg length at age 16 if the given combinations of variables at ages 7 and 12 are used for prediction purposes.

Inspection of the table shows that, in general, the residual variances are smaller (i.e., the predictions are better) when the predictions are made from the measurements at age 12 rather than from those at age 7. This is not surprising since growth is more nearly complete at age 12. The single exception occurs when the prediction is made from height alone. Leg length at age 16 is better predicted from height at age 7 than from height at age 12.

Various combinations of the variables, height, leg length and ratio, have been used as the bases for the predictions of leg length at age 16. When

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the predictions are made from measurements at age 7, residual variances of 7.12 or less are observed for five out of the possible seven combinations of the three variables. The residual variances for the five combinations

TABLE 4
*Regression Equations and Residual Variances for
the Prediction of Leg Length at Age 16*

	Height	Leg Length	Ratio	Constant	Residual Variance
<i>Predictions from age 7</i>					
<i>From 3 variables</i>					
Leg length at age 16 =	+ .517H ₇	- .395L ₇	+ 173.5R ₇	- 43.8	6.92
<i>From 2 variables</i>					
L ₁₆ =	- .047H ₇	+ .898L ₇		+ 32.2	7.11
L ₁₆ =		+ .733L ₇	+ 36.3R ₇	+ 19.1	7.06
L ₁₆ =	+ .341H ₇		+ 124.3R ₇	- 21.8	6.94
<i>From 1 variable</i>					
L ₁₆ =		+ .828L ₇		+ 30.3	7.12
L ₁₆ =	+ .480H ₇			+ 17.8	8.32
L ₁₆ =			+ 213.6R ₇	- 21.2	9.36
<i>Predictions from age 12</i>					
<i>From 3 variables</i>					
L ₁₆ =	- .450H ₁₂	+ 1.439L ₁₂	- 5.1R ₁₂	+ 42.3	4.52
<i>From 2 variables</i>					
L ₁₆ =	- .435H ₁₂	+ 1.407L ₁₂		+ 39.9	4.52
L ₁₆ =		+ .525L ₁₂	+ 127.8R ₁₂	- 23.2	4.74
L ₁₆ =	+ .245H ₁₂		+ 205.6R ₁₂	- 59.4	5.05
<i>From 1 variable</i>					
L ₁₆ =		+ .703L ₁₂		+ 25.2	6.23
L ₁₆ =	+ .295H ₁₂			+ 31.5	10.25
L ₁₆ =			+ 232.2R ₁₂	- 35.4	8.33

range from 6.92 (height, leg length and ratio) to 7.12 (leg length alone) and do not vary effectively. It would seem that leg length at age 16 can be as effectively predicted from leg length at age 7 as it can from leg length, height and ratio at age 7. Knowledge of the height and ratio at age 7 does not seem to increase the accuracy of the prediction.

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The situation is practically the same when the predictions are made from measurements at age 12. Combinations of two of the variables appear to be as effective as the three used simultaneously. The residual variances range from 4.52 to 5.05. Leg length alone with a residual variance of 6.23 seems to be only slightly less effective.

Comparison of the regression coefficients in the two equations which involve the three variables shows that there are large differences between the coefficients. Height, for example, at age 7 has a regression coefficient of $+0.517$, while height at age 12 has a coefficient of -0.450 . The differences between these coefficients is more apparent than real since the coefficients in either of the equations are themselves correlated, and within a correlated system, different proportions of the total variance will be thrown from one to another of the variables by minor sampling variations (4).

EFFECT OF AGE OF FIRST MENSTRUATION ON THE PREDICTIONS

It has been shown in the preceding section that very little additional accuracy in the prediction of leg length at age 16 can be obtained from the knowledge of the height and ratio at ages 7 or 12 than can be obtained by the knowledge of leg length alone at ages 7 or 12. Shuttleworth, in studying the material from which these 200 cases were selected, has found that "the menarche is associated with (a) physical size and (b) the timing of changes in the differential patterns of physical growth." The age of the first menstruation is known, unfortunately, for only 64 out of the group of 200 girls studied here. Nevertheless, it is of some interest to determine how the prediction of leg length at age 16 is affected by the menarche in this small group. Table 5 presents the information which relates to this group. Comparison with Table 1 shows that these 64 girls for whom the menarche is known are, on the average, slightly taller and have slightly longer legs than the group of 200 from which they come. While these differences are not "statistically significant," they do suggest that this small group does not constitute a random selection from the larger group of 200. Table 5 shows that the leg lengths and the heights at a given age vary with the age of the first menstruation. Shuttleworth has discussed the character of this variation in detail on the basis of the larger series. The ratios at a given age do not show the same pronounced variation with the menarche as do the heights or the leg lengths.

The table gives two series of values for the predicted leg lengths at age 16. These predicted values were obtained from the two regression equations which involved the three variables, height, leg length and ratio at ages 7 and 12 respectively. The last two columns of the table show the average differences between the observed and predicted values of leg length at age 16 for the six groups of girls whose menarches occurred at the

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stated ages. That these differences are systematic is obvious. The predictions of leg length at age 16 for girls whose first menstruation occurs early are too high while the predictions for girls whose first menstruation occurs

TABLE 5
Leg Length, Height and Age at First Menstruation

Age of first menstruation	Number in group	Leg length in cms. at age			Height in cms. at age		
		7	12	16	7	12	16
Before 11-6	7	55.0	73.4	74.8	121.4	154.6	160.3
11-6 to 11-11	6	56.6	74.1	74.3	124.1	156.1	160.3
12-0 to 12-5	10	56.2	73.0	74.8	124.2	155.7	161.0
12-6 to 12-11	14	55.6	73.7	76.2	122.3	153.9	161.6
13-0 to 13-5	21	56.0	73.4	76.7	122.1	152.2	162.9
After 13-6	6	53.4	71.8	77.1	118.8	149.4	163.6
TOTAL	64	55.65	73.33	75.89	122.28	153.48	161.86

Age of first menstruation	Ratio at age			Leg length at age 16 predicted from ages		Observed—Predicted leg length at age	
	7	12	16	7	12	7	12
Before 11-6	.454	.475	.468	75.9	76.0	-1.10	-1.16
11-6 to 11-11	.454	.475	.461	76.8	76.3	-2.49	-1.99
12-0 to 12-5	.454	.469	.464	76.9	74.8	-2.13	-.08
12-6 to 12-11	.455	.479	.471	76.4	76.7	-.22	-.54
13-0 to 13-5	.458	.482	.471	76.6	77.0	.08	-.27
After 13-6	.450	.480	.471	74.6	75.9	2.55	1.23
TOTAL	.4552	.4776	.4688	76.35	76.30	-.46	-.41

late are too low. This statement is true irrespective of which of the regression equations presented in Table 3 is used. The residuals from the equations involving ratio alone behaved less systematically than do those from the other equations, but the residual variances from these equations were, themselves, large.

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SUMMARY

Certain material from the Harvard Growth Study relating to the growth of leg length and the prediction of leg length at age 16 has been analyzed. It appears that accurate predictions at age 16 cannot be made from leg length, height and ratio at ages 7 or 12. Consequently, if the predictions are to be made more precise, it becomes necessary to consider other variables. Age of the first menstruation is apparently one variable which influences the prediction considerably; but if the predictions are to be made from age 7, this variable will not be known.

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PREDICTION OF ADULT STATURE

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The Problem. The physician is often faced by an anxious mother leading a daughter whom she fears is going to be too tall, or a son whom she fears is going to be too short. Usually no physical disorder can be detected, and therefore the physician's part resolves into reassurance. This he can do more convincingly when he has a method of forecasting the child's probable adult height. Several such methods will now be discussed: Height for age (8, 9), mid-parent rule, Bayley's (1, 2, 3, 4) bone-age method, Walford's transformation (11).

Height for Age. The time-honored method has long been to plot the child's stature and compare it with some so-called normal curve. A considerable choice of such standards is available in the pediatric journals but notably fewer in the text-books. The authorities differ markedly, so that even when the physician goes to the pains of picking the standard most appropriate to the child in question, the comparison would prove so unconvincing or depressing to the mother that he prefers to dismiss printed standards as arbitrary and to reassure her on his own authority. Nevertheless, emphasizing firmly the proviso of selecting a table based on children of racial and environmental similarity to the patient, a reasonable estimate can often be stated for the expected zone of normal variation for the child's present age. Often this estimate indicates no extreme stature and reassurance is simple. Or when the predicted value deviates markedly from the general run, say in the lowest or highest 5 per cent of heights for that age, then one can recommend special attention to diet, vitamins, avoidance of infections; and, when they occur, more diligent attention to them than would be necessary ordinarily. Above all, the doctor should see the child every three months for a year or more; partly to watch the rate of growth, but also to win the child's confidence and trust, in order to lead him to accept his difference from the average as "one of those things," i.e., one of those personal variations that we all have to face sooner or later and make the best of.

Mid-parent Rule. The stature of the parent of the other sex than the child is converted to a same-sex estimate, reducing the father's height by $12/13$; i.e., 0.923 , or enlarging the mother's height by $13/12$; i.e., 1.08 (7). For example, for the girl J. in Table 2 below, the father's height 1819 mm. $\times .923$ was 1679 , the female equivalent. Averaging this with the mother's 1659 , we predict for the child 1669 mm. Since at the age of 25 she was 1683 mm. tall, this prediction was 14 mm. or 0.8 per cent too small. The forecast in this case was gratifying. The general precision of this method has never been studied, but may be roughly estimated from

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the evidence in the 53 cases here collected. The percentage error varied from 8.4 too small to 1.4 too large, and averaged without regard to sign 2.8 per cent.

Bayley's Bone-age Method. In a study exceptional for comprising observations of many characteristics from birth to maturity (2), she demonstrated that mature size can be predicted with notable accuracy if a child's present size and skeletal age are known. There also appeared to be one type of comparison in which sex differences practically disappeared; when she controlled the degree of skeletal maturity, by adjusting for the two-year sex difference in bone maturity during these adolescent years, then the growth curves for per cent of mature height were closely similar for the two sexes.

Dr. Bayley has kindly furnished annual statures on 21 boys and 22 girls. These amplified the smaller series which I had collected of ten cases, unfortunately lacking bone-ages, but making 53 in all for various parts of this study. Now, on applying Walford's transform, which is treated in the next section, I predicted mature heights by use of her measurements through the sixth birthday in 3 cases, the seventh in 3, the eighth in 9, the ninth in 12, the tenth in 7, the eleventh in 4, the twelfth in 3, and the thirteenth birthday in 2 cases. Then, for comparison, Dr. Bayley was asked to make her predictions, availing herself only of her standards up to those respective ages. The deviation or error, expressed as a percentage of the latest observed height, which is assumed in this paper to be approximately the adult value, came out as follows. Her predicted values were sixteen times on the plus-side and twenty-seven on the minus-side; i.e., her method tended slightly to underestimate the future mature height. The error ranged from plus 3.3 per cent to minus 7.3 per cent, and the average for the 43 children without regard to sign was 2.0 per cent. When the latest age allowed her for prediction was the 6, 7 or 8th birthday, her error averaged 1.8 per cent, and when the 9th, 10th, 11th, 12th or 13th birthday, the error averaged 2.2 per cent; rather the reverse of what would be expected. Since the errors of methods current in the practice of medicine are of the order of 5 per cent, or even 10 per cent, the average just found is admirable. Also is was smaller than the 2.7 per cent error resulting from applying the transform to these same cases.

Walford's Transformation. This ingenious device can be applied graphically, and then if desired computed more exactly. One merit is that it requires only annual heights and saves the expense of bone-ages by X-ray. Another merit is that the graph yields a straight line, which is much simpler to interpret than the conventional curved lines for height on age. The error of prediction will be shown later in this paper.

The essence of Walford's device, instead of the conventional manner with age on the horizontal, and stature on the vertical scale, is to plot stature at a given birthday on the x -axis and stature at the next birthday on

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the y -axis. As many such points are plotted as there are available heights at yearly intervals. He noticed, on omitting some points out of the stream, that a line fitted by least squares to the remaining points evidenced by its slope the percentage relative rate of growth, apparently *fixed early in the life of the individual*.

His working-units were the actual measurements in millimeters, and his data were group-averages. His principle is extended in this paper both to series of group-averages and to series for different individuals, plotting each series and computing the straight growth-line. And this was done both in his working-units of millimeters of height, and also in natural logarithms of those heights. Theoretically, the log units, which define the instantaneous percentage growth-rate, have been advocated as superior by sundry writers (5, 9). And practically, the parallel trials mentioned yielded smaller errors in prediction for the log units. This modification of Walford's transformation will now be presented in detail, and will be referred to as the transform.

METHOD PROPOSED FOR HEIGHT-PREDICTION

The successive steps of the procedure here advocated, will be demonstrated as a paradigm (Table 1).

1. Age is shown in the first column. For the particular series here shown it is the center of the age-range, e.g. 1 = 0.5 to 1.5 years. For the study of an individual the measurement should be made on or near the birthday; if not, then one takes a large sheet of cross-section paper about 21×16 inches, ruled 10 lines to the inch, such as Dietzgen's No. 360, plots the heights against ages and fractions as exactly as possible, fits a smooth curve with a spline, reads off heights at even birthdays, and lists these in column 2.

2. Stature, in the second column, is a series of statures used, here the averages, for varying numbers of private school girls, 1466 in all (6). They have been plotted and smoothed graphically with resulting slight adjustments of the original averages for the ages 13, 15, 17, and 18.

3. The natural logarithm of stature, or, for convenience in entering a Table of Natural Logarithms (the best is given in References (10)), $\ln(S/1000)$, is read off and listed in column 3. Each of these is the value x at a given age A , corresponding to Walford's length l at age n . The abbreviation A is here preferred to n , because that is so universally used to denote the number of cases.

4. The logarithm of stature one year later, denoted as y at age $(A + 1)$, corresponding to Walford's length at age $(n + 1)$ is entered on each line in column 4 by reading from the prior column the value on the next lower line. Then the data x, y are used for plotting and computing throughout, until the very end, when the final predicted limit of growth will be re-converted by the table into millimeters of stature.

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5 and 6. The extensions x^2 , xy were carried out to 6 decimal places, so that the totals come from those original calculations and occasionally differ slightly from the totals of the items in the paradigm table.

TABLE I
1466 Private School Girls

Age (1)	Stature in mm. (2)	x (3)	y (4)	x^2 (5)	xy (6)
1	754	-.2824	-.1578		
2	854	-.1578	-.0419		
3	959	-.0419	.0344	.0018	-.0014
4	1035	.0344	.1053	.0012	.0036
5	1111	.1053	.1664	.0111	.0175
6	1181	.1664	.2159	.0277	.0359
7	1241	.2159	.2677	.0466	.0578
8	1307	.2677	.3067	.0717	.0821
9	1359	.3067	.3373	.0941	.1034
Sums:		1.0545	1.4336	.2541	.2989
Means:		.1506	.2048		
10	1401	.3372			
11	1461	.3791			
12	1520	.4187			
13	1568	.4498			
14	1601	.4706			
15	1620	.4824			
16	1629	.4880			
17	1635	.4916			
18	1640	.4947			
19	1646	.4983			

7. Lay-out of the diagram. Take a sheet of paper ruled 10 to the inch, such as the common 10 \times 8 inch size, and beginning at the left lower corner, lay off identical scales covering the range of values from the first to the last in column 3. Usually, at each heavier inch ruling, the figures

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will be: $-.30, -.20 \dots 0, .10, .20 \dots 50$. Thus we get a lay-out like Figure 1.

8. The 45 degree line. From the joint origin of the scales in the left lower corner, draw a 45-degree diagonal up across the diagram. Its theory was given by Walford but can be ignored by us. Its practical use will be seen later.

9. Plotting the points. From the first row recorded, the values x, y are plotted as a circle about 1-2 mm. in diameter, and this process is repeated for each successive row.

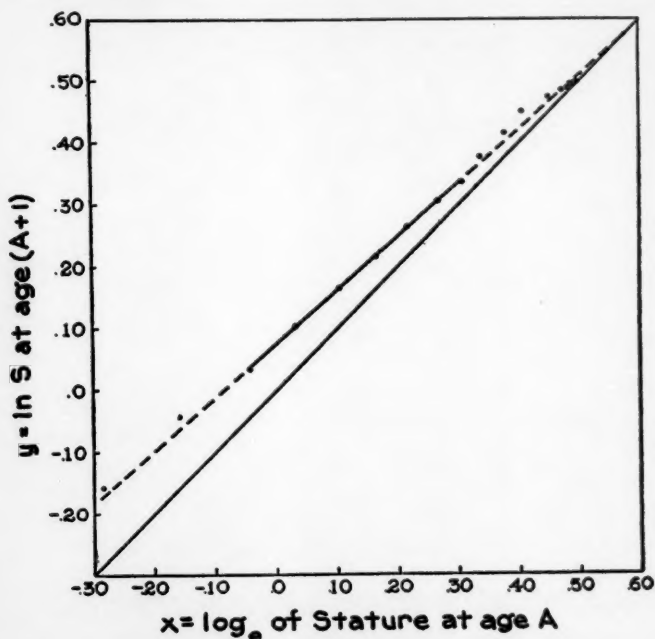


FIGURE 1

10. The preliminary prediction-line by eye. Inspection of the stream of points will now show some remarkable phenomena.

(a) At earlier ages, i.e., to the left, a couple of circles usually lie plainly above the line, and are to be neglected.

(b) At later ages of adolescence, i.e., off to the right, the circles take the course of a curve, first up then down again until they meet the prediction line to be defined. They also are to be neglected.

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(c) This is the cardinal feature. An impressive number of the circles lie so nearly in a straight line that they touch a celluloid straight-edge. The number of these varies from 3 to 10 and usually corresponds to the range of ages 4 to 9 years, occasionally 2 to 12 years. In the present series the range is for the 7 circles from ages 3 to 9 in column 1. This line is ruled in heavy over this range, and dashed off to the left, and to the right until it joins the 45-degree diagonal. The value at the junction reads identically on both axes; i.e., $x = y$, that is, the value at some age A (just what age, is secondary) will be equal to that at next age $(A + 1)$. That value will be mature height, as near as can be forecast graphically. Now we shall get it more accurately by computing.

11. The equation for the prediction-line. We return to Table 1 and rule two lines across to delimit the range of 7 rows specified in the preceding paragraph. We add columns 3, 4, 5, 6 to get the sums $S(x)$, $S(y)$, $S(x^2)$, $S(xy)$. These sums, and the number of points $n = 7$, enable us to compute the conventional formula for k , the slope of the regression line:

$$k = [S(xy) - n \bar{x}\bar{y}] / [S(x^2) - (Sx)^2/n],$$

whence $k = .872$, and E the expected value of y at any x is:

$$E = \bar{y} - k\bar{x} + kx = .0735 + .872x;$$

which, it is to be emphasized, is the value of y at *any* x .

12. The limiting length. The exact value of y when it equals x , i.e., where the main line joins the 45-degree diagonal, where growth ceases, is easily got by Walford's equation 5, which may be written:

$$L = \text{intercept}/(1 - k) = (\bar{y} - k\bar{x})/(1 - k) = .0735/.128 = .574;$$

which agrees with the graph. This logarithm could now be re-converted to 1776 mm., but that is plainly too large, as is also the case with the 53 individuals studied; the reason is that this limiting value L theoretically estimates the asymptote approached as a limit, but certainly not actually attained until after tiny gains in the 20's or even 30's and practically turns out therefore always larger than the height actually observed at the so-called adult age of say 20 years. Therefore, a further modification of Walford's work is needed by the introduction of a correction factor.

13 a. Correction factor and corrected limiting length (female). We may take

$$c = \text{observed/predicted} = \text{adult } x/L, \text{ here } .4983/.5742 = .8678,$$

which is therefore recommended as a correction to improve the limiting equation calculated from *any* female series, whether a series of group aver-

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ages or a series of heights for one individual girl. The corrected limit or final forecast of adult height is:

$$cL = .8678L = .8678(\bar{y} - .872\bar{x}) / (1 - .872) = 6.7793\bar{y} - 5.9115\bar{x},$$

which should estimate a corrected limit identical with the natural log of the oldest stature listed, what I called the "adult" x ; that was .498, and solution of the above equation gives the same. For other female series, naturally, this fixed correction factor does not yield a perfect outcome, but it seems the best overall estimate at present. The \bar{x} and \bar{y} are got from the calculations for the individual under examination. These successive steps are displayed in Table 2.

TABLE 2

Work-Sheet for Girls

Assuming slope $k = .872$, i.e., that found from Private School Girls, and similarly correction = .8678

		Pri. Sch.	Joan	Barbara	Peggy	Bayley's No. 120
1)	\bar{y}	.2048	.2100	.1886	.2230	.1560
2)	\bar{x}	.1506	.1489	.1195	.1587	.0916
3)	$k\bar{x}$	.1313	.1298	.1042	.1384	.0799
4)	$\bar{y} - k\bar{x}$	.0735	.0802	.0844	.0846	.0761
5)	$(\bar{y} - k\bar{x}) / (1 - k) = \log_e L$	.5742	.6265	.6593	.6609	.5945
6)	$\log_e(\text{latest "adult" } S/1000)$	.4983	.5206	.5895	.5755	.5092
7)	$(6)/(5) = \text{corr. factor}$	.8678	.8678	.8678	.8678	.8678
8)	$(5) \times \text{factor} = \log(cL)$	.4983	.5437	.5721	.5735	.5159
9)	$[(8) - (6)] / (6)$	0	+4.4	-3.0	-0.3	+1.3
10)	Solution of Equation in Paragraph 13 = $\log(cL)$	.4981	.5435	.5722	.5736	.5161

13 b. Correction factor and corrected limit (male). The same procedure applied to 3110 private school boys, gives the correction factor $c = .9411$ and the corrected limit or the final prediction of mature height as:

$$cL = .9411L = 7.842\bar{y} - 6.901\bar{x}.$$

14. Slope assumed constant for sex. When we proceed to the study of individuals, we find of course that the slope varies from person to person. One might be disposed to use for each the personal slope. Unfortu-

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nately in some children the graphic line is nearly parallel to the 45-degree line, i.e., its slope approximates 1.00. In such instances the lines will take so long to meet that the mature value is obviously ridiculous, and the method fails us. Judging from several trials, any series of points yielding a calculated regression line with a slope of .90 or more indicates that that child's line is too nearly parallel to the 45-degree line, therefore would predict an absurd adult height, and makes the method useless for that particular child. Hence one is led to consider using a constant slope for the sex. Trial of this hypothesis has shown that the error of prediction is reduced and simplicity is greatly increased. An obvious assumed value of the slope k constant for females is that magnitude just computed for the series of private school girls. So with $k = .872$ the individual series were computed, and 4 of them are shown in the table as examples. The corresponding k from the series of private school boys was .880.

Another assumption for a fixed k might be the average of k 's obtained from a number of individual series; thus from 11 female series taken at random the average k was .850, which is reasonably close to .872, the value chosen; and for 9 male series the average slope was .890, which again is satisfactorily near to .880 as chosen; this alternative assumption was not used in the present work.

15. Error of proposed method. To measure this for each individual we take $100(cL - \text{Obs.}) / \text{Obs.}$, where cL is the corrected limit predicted and Obs. is the observed "adult height." In passing it may be noted that in our female series the ages ran from 15 to 25, average 18.3, and in the male series 17 to 22, average 18.1 years.

The percentage errors for 29 girls varied from -7.2 (too low prediction) to +5.5 (too high forecast), with an average disregarding sign, of 2.5. For 24 boys, the percentage errors ran from -8.0 to +5.3, averaging without regard to sign 2.4. For all 53 the average error was 2.5.

16. Final predicted adult stature. The last step is to reconvert the logarithmic working-units into original units of millimeters to obtain the desired adult size or limit of length, which Walford terms length at infinity and here is written more simply as L .

SUMMARY

Three methods of forecasting the adult stature in children are presented. The respective percentage-errors of prediction were:

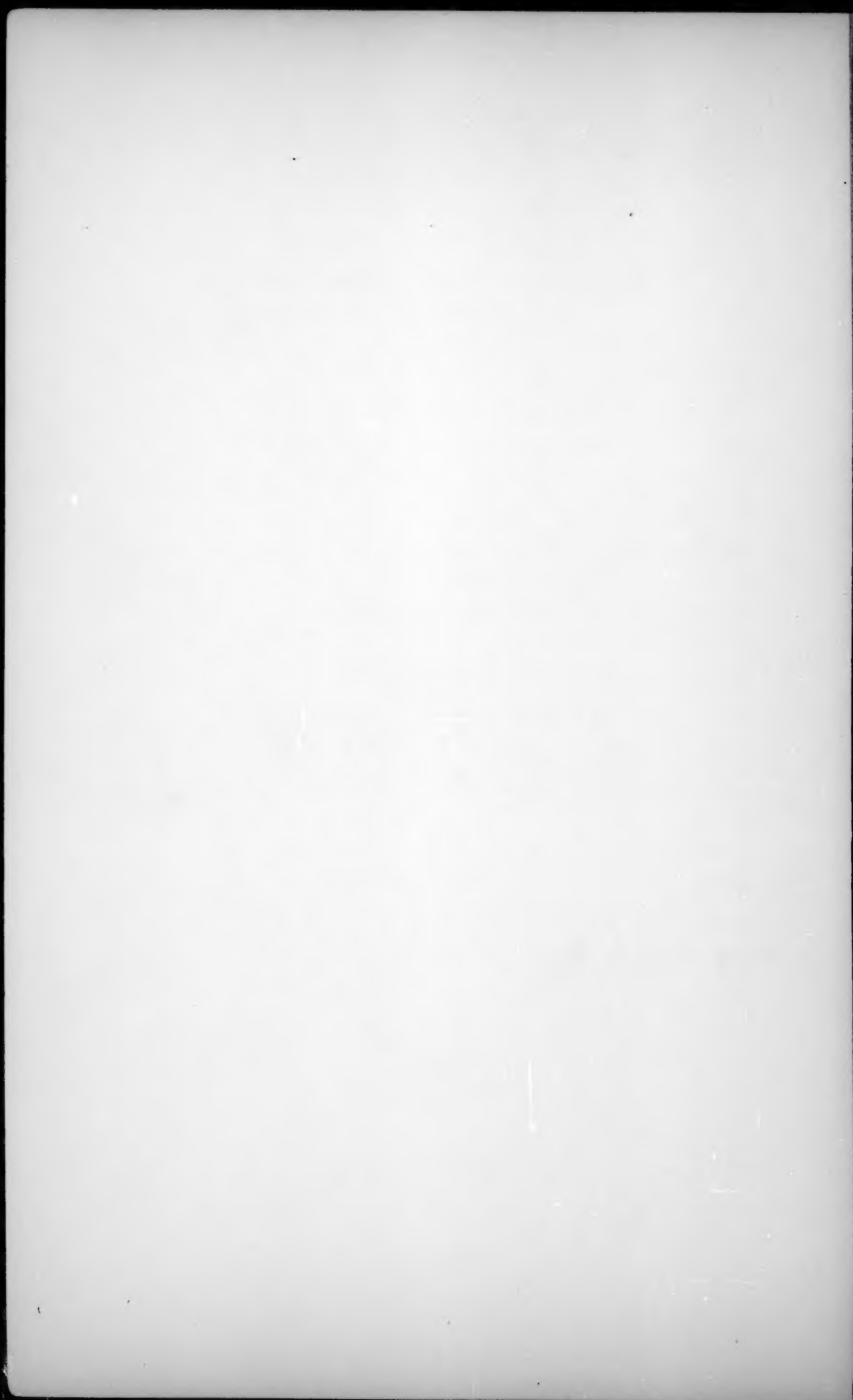
Mid-parent rule	2.8
Walford's transform	2.5
Bayley's bone-age	2.0

The last named method is the best, but none the less the other two may at times be serviceable.

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